

**Nominal Exchange Rate Misalignment:  
Is It Particularly Important to Agricultural Trade?**

Gue Dae Cho  
MinKyoung Kim  
Edwin Sun  
Hyun Jin  
Won W. Koo



Center for Agricultural Policy and Trade Studies  
Department of Agribusiness and Applied Economics  
North Dakota State University  
Fargo, North Dakota 58105-5636

## ACKNOWLEDGMENTS

The authors extend appreciation to Dr. Robert Hearne, Mr. Richard Taylor, and Mr. Jeremy Mattson for their constructive comments and suggestions. Special thanks go to Ms. Beth Ambrosio, who helped to prepare the manuscript.

The research was conducted under the U.S. agricultural policy and trade research program funded by the U.S. Department of Homeland Security/U.S. Customs and Border Protection Service (Grant No. TC-02-003G, ND1301).

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## **Abstract**

This paper examines whether exchange rate misalignment negatively affects agricultural trade, compared to other industry sectors. Nominal exchange rate misalignment is obtained from the percentage deviation of real exchange rates from their long-run equilibrium based on the theory of purchasing power parity. In order to explore this issue, a bilateral trade matrix involving trade flows between 10 developed countries is constructed. Using panel data analysis, a gravity model is estimated for 4 industry sectors over the period 1974-1999. The study finds that over-valuation (under-valuation) of the nominal exchange rate negatively (positively) affects export performance of the agricultural sector in particular. In the large-scale manufacturing sectors considered in this paper, exports are not significantly affected by exchange rate misalignment.

**Keywords:** exchange rate misalignment, agricultural trade, and gravity model.

## Highlights

The effect of exchange rate misalignments on international commodity trade has been one of the most important issues in international economics. Many empirical observations suggest the existence of substantial and persistent exchange rate misalignment among developed countries under the floating exchange rate system.

Agricultural products are mostly homogeneous and perishable. Due to these special characteristics, we expect that the effect of misalignment on agricultural trade is larger than that on large-scale manufacturing sectors. Relevant literature also predicts an asymmetric effect of exchange rate shock on different industry sectors.

Using a gravity model, this paper addresses the effect of exchange rate misalignment on agricultural trade and compares the impact to that in other sectors. By employing a panel data set, we can efficiently estimate both time-series and cross-sectional difference of exchange rate misalignment on international trade. The data used in this study are comprised of bilateral trade flows for 10 developed countries during the period of 1974-1999. Four different industry sectors, including the agricultural sector, are considered and their empirical results are compared.

The study finds that over-valuation (under-valuation) of the nominal exchange rate negatively (positively) affects export performance of the agricultural sector in particular. In the large-scale manufacturing sectors considered in this paper, exports are not significantly affected by exchange rate misalignment.

In fact, nominal exchange rates have followed their long-run equilibrium path so that they are cyclically misaligned at best. Therefore, unlike a short-run effect, the major problem for international agricultural trade caused by exchange rate movement is instability in the long-run. Cyclical booms and depressions of agricultural exports by countries could possibly increase resource-waste within the agricultural sector, resulting in larger dead-weight costs compared to other large-scale industrial sectors.

# Nominal Exchange Rate Misalignment: Is It Particularly Important to Agricultural Trade?

Gue Dae Cho, MinKyoung Kim, Edwin Sun, Hyun Jin, and Won W. Koo\*

## INTRODUCTION

The effect of exchange rate misalignments on international commodity trade has been one of the most important issues in international economics. Many empirical observations suggest the existence of substantial and persistent exchange rate misalignment<sup>1</sup> among developed countries under the floating exchange rate system (e.g., Dornbusch, 1987; Rogoff, 1996; Frankel, 1996). Although many agricultural economists (e.g., Gardner, 1981; Tweeten, 1989) have, in fact, investigated the potential impact of misalignment on international agricultural trade, there are still two remaining questions related to this topic.

The first question is how to examine the effect of *relative* movements of exchange rate misalignments on international trade. For example, when a country's currency is overvalued compared to past periods, it does not necessarily negatively affect the country's exports. If the overvaluation is relatively less than that of all competitors, it is even possible to find a positive correlation. According to the theoretical model suggested by Wolak and Kolstad (1991), the relative movement of import price is one of the important factors affecting the choice of an importer. Because exchange rate is one of the most important factors determining relative import prices, relative exchange rate movements should be treated as important factors influencing imports/exports of a country. A time-series approach, however, does not incorporate the relative movements in the exchange rate; this is a serious omission that could result in biased and misleading estimations. Commodity trade, especially agricultural trade, is highly volatile due to weather and political conditions in importing and/or exporting countries. The estimated coefficients of the model with pure cross-sectional data for a particular year may not provide accurate information in evaluating trade flows of a commodity (Koo et al., 1994). Therefore, combining time-series and cross-sectional data is the most comprehensive method to resolve this issue.

A second question concerns the importance of exchange rate misalignment in different sectors of an economy. Is it more vital to international agricultural trade than to the manufacturing sector? If exchange rate misalignment has the same effect on all industry sectors in a country, there is no particular reason we should treat the agricultural sector separately. However, there are some reasons to believe that misalignment affects international agricultural trade more seriously. For instance, the recent literature related to strategic behavior of firms responding to exchange rate shock suggests that traders strategically decide their export price

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\* Research Assistant Professors, and Professor and Director of the Center for Agricultural Policy and Trade Studies, North Dakota State University, Fargo.

<sup>1</sup> Misalignment, in general, refers to the departure of nominal exchange rates from long-run equilibrium level or market fundamentals such as relative prices and interest rate differentials between countries.

based upon exchange rate movements (Goldberg and Knetter, 1997). It has been generally observed that, when there has been substantial over- (under-) valuation of an exporter's currency, exporters do not fully increase (decrease) their export price, denominated in the destination country's currency.<sup>2</sup>

In short, two theoretical models explaining the motivations behind exporters' strategic behavior are considered in the relevant literature. Baldwin (1988) suggests a supply-side explanation. Assuming the existence of an irreversible initial sunk cost to enter a foreign market, he shows that because of the initial investment cost, even a substantial over-valuation of an exporter's currency does not in itself compel firms to leave the destination market. If they decide to stay, firms adjust their price based on the condition of market competition in the destination country.<sup>3</sup> Froot and Klemperer (1989) emphasize the exporting firm's motivation to keep their market share in a destination market. In the case of a durable good, they argue that consumers face substantial costs in order to switch between brands of a product, even if the brands are functionally identical. Due to the switching cost, the current market share is an important determinant of the future market share. Exporters are aware of this consumer behavior and, in order to keep their market share, they do not change the product price as it is denominated in the destination market currency even when there is an overvaluation of exporters' currency.

Many empirical studies investigating the manufacturing sector (e.g., Knetter, 1993) have found exporting firms engaging in price adjustment behavior. However, it is important to note that these cases are not well-fitted to explain agricultural trade. This is because agricultural goods are mostly substitutable and often non-durable; moreover, the initial investment cost to enter a foreign market is not as important as it is in the industrial sector. Therefore, compared to manufactured goods, there is a strong possibility that agricultural trade is more sensitively responsive to exchange rate movement.

Although these are important issues, there are few empirical studies which examine them. Exceptions are Bergstrand (1985, 1989), Koo and Karemera (1991), and Koo et al. (1994). In his earlier papers, Bergstrand investigated this issue using a generalized gravity model with cross-sectional data. His empirical results, however, were not consistent with economic intuition. Although he found weak evidence that *relative* exchange rate movements have an important role in explaining trade flow in the case of the total trade, results were mixed in the case of sectoral trade. In 9 out of 36 cases, he found the expected sign of the variable; however, in 12 out of 36 cases, he found exactly the reverse sign of the estimated coefficient. One of the potential drawbacks of his empirical research was that he used relative nominal exchange rate movements, which are not economically meaningful indicators under the floating exchange rate system.

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<sup>2</sup> This is called "incomplete or partial pass-through of exchange rates" or "pricing to market" (PTM) behavior of exporting firms in the relevant literature.

<sup>3</sup> Dornbusch (1987) also shows that the price adjustment of exporting firms should depend on at least three factors: the degree of market concentration, the relative market shares of domestic and foreign firms, and, most importantly, substitutability of the product.



Using a gravity model, this paper addresses the effect of exchange rate misalignment on agricultural trade and compares its impact to that in other manufacturing sectors. By employing a panel data set, we can efficiently estimate both time-series and cross-sectional differences of exchange rate misalignment in international trade. The data used in this study are comprised of bilateral trade flows for 10 developed countries during the period of 1974-1999. Four different industry sectors, including the agricultural sector, are considered and their empirical results are compared.

The paper is organized as follows. Section 2 outlines the relevant aspects of exchange rate misalignment, and Section 3 presents a discussion of relative exchange rate misalignment. In Section 4, variable construction and data are discussed, while in Section 5, the econometric specification and results are reported. The principal results are summarized in Section 6.

## EXCHANGE RATE MISALIGNMENT

Exchange rate misalignment can be defined as the departure of the nominal exchange rate from its long-run equilibrium level, where misalignment can be characterized as either over- or under-valuation of the currency relative to fundamentals. Measuring misalignment is difficult and inherently imprecise, as it requires estimation of what is termed the fundamental equilibrium exchange rate. Typically in the literature, it is assumed that purchasing power parity (PPP) is the long-run equilibrium condition of nominal exchange rates.<sup>4</sup> Essentially, PPP should hold because exchange rates equalize relative price levels in different countries. The standard expression for *absolute* PPP is:

$$s_t = p_t - p_t^*, \quad (1)$$

where  $s_t$  is the home currency price of a foreign currency,  $p_t$  is the domestic currency price of a particular good(s),  $p_t^*$  is the foreign currency price of the good(s), and lower case letters denote logarithmic values. The implication of (1) is that trade of goods will result in identical prices across countries. Allowing for factors such as transport costs, PPP in its *relative* form implies that a stable price differential should exist for the same good(s) selling in different countries, implying that real exchange rates between countries should be constant in the long-run, and consequently there is no misalignment of exchange rates from relative PPP, i.e., the real exchange rate should be mean-reverting (MacDonald, 1999).

In more recent research, the focus has been on the use of co-integration methods applied to the following equation:

$$s_t = \mathbf{b} + \mathbf{a}_0 p_t + \mathbf{a}_1 p_t^* + \mathbf{j}_t \quad (2)$$

If  $s_t$ ,  $p_t$ ,  $p_t^*$  are integrated of order one, I(1), then a weak form of PPP exists if the residual term from estimation of (2) is stationary, I(0). A stronger form of PPP exists if homogeneity is satisfied, i.e.,  $\mathbf{a}_0 = 1$  and  $\mathbf{a}_1 = -1$ . Using this type of approach, several early studies found no

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<sup>4</sup> Although PPP is typically used as the concept against which to gauge misalignment, it is not the only measure. There have been more formal attempts to measure the equilibrium exchange rate based on an explicit characterization of fundamentals.

evidence of significant mean-reversion of exchange rates toward PPP (Mark, 1990; Fisher and Park, 1991). However, several authors have argued that the data period for the recent float is too short to have any confidence in the power of statistical tests for stationarity of real exchange rates (Lothian and Taylor, 1997). As a consequence, recent research has been based on either long-term pre-float data (Lothian and Taylor, 1996) or multi-country panel data (Flood and Taylor, 1996; Frankel and Rose, 1996).

This more recent evidence rejects the random walk hypothesis of real exchange rates. Essentially, real exchange rates revert to equilibrium values over the long-run, and, correspondingly, nominal exchange rates and relative inflation rates between two countries converge. This revives the notion that PPP is a long-run equilibrium condition of nominal exchange rates (MacDonald, 1999), although consensus estimates suggest that the speed of convergence to PPP is very slow, the deviations appearing to dampen out at a rate of roughly 15 percent per year (Rogoff, 1996).

Specifically, if long-run PPP holds, as shown in (2), the nominal exchange rate,  $s_t = \mathbf{b} + \mathbf{a}_0 p_t + \mathbf{a}_1 p_t^* + \mathbf{j}_t$ ,  $\mathbf{a}_0 = 1$  and  $\mathbf{a}_1 = -1$ , and the underlying innovation,  $\mathbf{j}_t$ , should be a stationary process, which has mean zero and finite long-run variance,  $\mathbf{s}_j^2$ . The time-series movement of the estimated residuals,  $\mathbf{j}_t$ , can be thought of as the time-series movement of misalignment. Furthermore, under the assumption of long-run PPP, we can also express the equation as  $s_t - p_t + p_t^* = \mathbf{b} + \mathbf{j}_t$ . The left-hand side is simply the log of the real exchange rate,  $r_t$ , so that it can also be expressed as  $r_t = \mathbf{b} + \mathbf{j}_t$ . Since  $E(r_t) = \mathbf{b}$ , we can use the movement of  $\mathbf{j}_t (= r_t - \mathbf{b})$  as a proxy variable representing movements for misalignment.

## RELATIVE MOVEMENT OF EXCHANGE RATE MISALIGNMENT

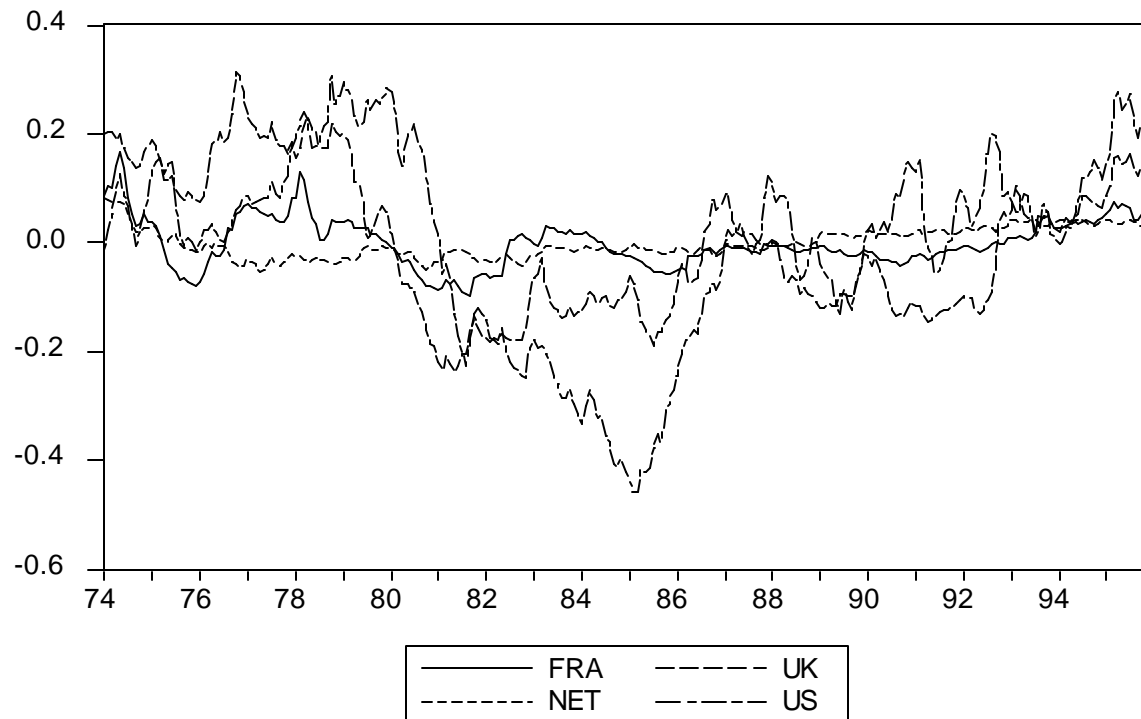
Figure 1 presents the movements in four different misalignments (franc/DM (FRA), guilder/DM (NET), pound/DM (UK), and dollar/DM (U.S.)) calculated based on the PPP. Percentage deviations of exchange rates from their sample average are calculated for comparison. By using percentage deviations from the equilibrium exchange rates, we can normalize different currency units and compare movements of relative misalignments with a unified measurement.

In the figure, we can easily observe that Germany has faced different degrees of misalignment with each trading partner during the sample period. For instance, in the mid-1980s, the German Mark was undervalued compared to the U.S. dollar, which was expected to negatively affect U.S. agricultural exports to Germany. The U.S. dollar started to revert to its equilibrium level after 1985. However, for a German importer, the U.S. dollar was still highly overvalued compared to other trading partners. Even when the U.S. dollar weakened in comparison to the previous period, U.S. agricultural exports to Germany could possibly decrease further, based on the exchange rate movements of other competitors in the German market.

Another example is the movement in misalignment between Germany and the Netherlands. These countries faced a relatively small misalignment problem during the sample period. However, stable exchange rate movement between these countries alone cannot eliminate exchange rate effects on their bilateral trade. For instance, during the mid-1970s, the

U.S. dollar was undervalued in comparison to the German Mark. In this case, German traders imported products from the United States rather than from the Netherlands. Although there was no misalignment problem between the Germany and the Netherlands, relative misalignment among all competitors strongly affected trade flows between countries. If we were to only consider the movements of misalignment between Germany and the Netherlands using time series analysis, the results might be misleading.

**Figure 1. Movements of Misalignments in Comparison to the German Mark**



## ESTIMATION MODEL AND DATA SOURCES

The basic econometric specification used in this analysis is similar to those detailed in recent studies (Rose, 2000; Glick and Rose, 2001; Pakko and Wall, 2001). However, because our focus is on the level of movement in misalignment and sector trade, rather than variability<sup>5</sup>, it is proper to employ a gravity model used by Bergstrand (1985, 1989) and Feenstra et al. (2001). The basic specification of the model is

<sup>5</sup> In the usual gravity model, we cannot include the level of movement of misalignment because the dependent variable is the sum or product of exports (or imports) between countries.

$$\ln EX_{ijt}^k = a_0 + a_1 M_{ijt} + a_2 \ln Y_{jt} + a_3 \ln Y_{it} + a_4 \ln \left( \frac{Y_{jt}}{POP_{jt}} \right) + a_5 \ln \left( \frac{Y_{it}}{POP_{it}} \right) + a_6 \ln(DIST)_{ij} + a_7 BORDER_{ij} + a_8 LANG_{ij} + a_9 EU_{ij} + m_j + d_t + h_{ijt} \quad (3)$$

where  $EX_{ijt}^k$  is the real export value of country  $i$  to country  $j$  in year  $t$  for sector  $k$ , and where  $k$  refers to specific export sectors: 1=total exports, 2=machinery, 3=chemicals, 4=other manufacturing, and 5=agriculture.  $M_{ijt}^k$  is the proxy variable for the level of misalignment, which is calculated as the percentage deviation of real exchange rates from their sample mean ( $M_{ijt} = \ln R_{ijt} - \overline{\ln R_{ijt}}$ ). Because a positive (negative) value means over-valuation (under-valuation) of an exporter's currency by data construction, the expected sign is negative.  $Y_{it}$  and  $Y_{jt}$  are the annual real U.S. dollar value income of exporting country  $i$  and importing country  $j$ , respectively, over the sample period. The variable is expected to include both demand- and supply-side effects on bilateral trade, so that the expected signs are positive.  $\frac{Y_{it}}{POP_{it}}$  and  $\frac{Y_{jt}}{POP_{jt}}$

represent real per capita income (U.S. dollar value) of the exporting and importing countries.  $DIST_{ij}$  is distance between the exporting and importing countries.  $BORDER_{ij}$  is a dummy variable which identifies a common border effect (if there exists a common border, the variable is 1; otherwise, it is 0).  $LANG_{ij}$  is a dummy variable which identifies a common language effect (if there is a common language, the variable is 1; otherwise, it is 0). The other dummy variable,  $EU$ , is also included to account for trade between members of the European Union (EU), as we would expect membership in a customs union to have a positive impact on bilateral trade.

### **Variable Construction and Data**

This study uses annual data from 1974 to 1999. The variable  $EX_{ijt}^k$  is the real export value of country  $i$  to country  $j$  in year  $t$  for sector  $k$ , which refers to a specific export sector and is calculated in terms of the U.S. dollar and deflated using the U.S. consumer price index. The variable is constructed as follows: using the OECD bilateral trade data set taken from *Trade in Commodities* classified by one-digit standard international trade code (SITC), we collect nominal export values in U.S. dollars from  $i$  to  $j$  for each sector  $k$ . This is deflated by the consumer price index in the United States (1982-84=100) from the Bureau of Labor Statistics (BLS). The sectors considered in this study are: food and live animals (SITC 0: agriculture), chemical and related products (SITC 5: chemical), manufactured goods classified chiefly by material (SITC 6: manufacturing), and machinery and transport equipment (SITC 7: machinery).

The variable  $M_{ijt}$  is the measure of exchange rate misalignment between export country  $i$  and import country  $j$  at time  $t$ . The variable is constructed as follows. First, U.S. dollar-based real exchange rates, which are constructed from nominal exchange rate data from the International Monetary Fund (IMF) series and deflated by a U.S./home country consumer price index (normalized 1990=100), were obtained from the Economic Research Service (ERS) of the

U.S. Department of Agriculture (USDA). Bilateral real exchange rates between exporting and importing countries are based on taking the U.S. dollar-based real exchange rate for the importing country  $j$  and dividing by the U.S. dollar-based real exchange rate for the exporting country  $i$ , giving the cross-rate  $R_{ijt}$ . The measures of misalignment are based on theory and recent empirical evidence of PPP, which suggest that the real exchange rates among developed countries are mean-reverting. Therefore, deviation of real exchange rates from their sample averages could be treated as a measurement of movement in misalignments.

For each pair of real exchange rates, we calculated their sample averages,  $\overline{\ln R_{ijt}}$ , and then calculated the percentage deviation of real exchange rates from their sample averages ( $M_{ijt} = \ln R_{ijt} - \overline{\ln R_{ijt}}$ ), which we treat as measures of misalignment. The advantage of this measure is that by using a percentage deviation, we have a unified measure with which to examine the effect of relative movements of misalignment on international trade.

The gross domestic products and per capita domestic products data for each country are given in their nominal value in U.S. dollars from the *World Economic Outlook Database* (IMF, 2001), and are deflated by the U.S. consumer price index (1982-84=100). Finally, the distance data between countries are obtained from Rose's data set.<sup>6</sup> Given the sample of 10 countries, there is a cross-section of 90 bilateral trade flows (10 x 9), with annual data covering 26 years (1974-1999) for each trade flow, generating a complete panel of 2340 observations (90 x 26) for each sector  $k$ .

## ESTIMATION RESULTS

Although the choice of a proper econometric specification to estimate the gravity model with panel data is not simple, as indicated by Matyas (1997, 1998), Egger (2000), and Pakko and Wall (2001), one/two-way fixed or random effect models are popularly used (e.g., Koo and Karemera, 1991; Glick and Rose, 2001).

For this study, we used random effect models. There are two reasons why we employ the random effect model rather than the fixed effect model. First, as Glick and Rose (2001), and Head and Ries (2001) discussed, the fixed effect model ignores the common cross-sectional variation of the data by adding a set of country-pair specific intercepts or forming deviations from individual means; therefore, the results should be interpreted as time-series evidence.<sup>7</sup> The main focus of this paper is to estimate the effect of relative exchange rate misalignment on the export flow, as well as their time-series movements. Thus, if we employ the fixed effect model, the choice of estimator contradicts the primary economic question of the paper. Alternatively, by using the random effect model, we can utilize both time-series and cross-sectional information of the data.

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<sup>6</sup> Rose's data can be found on his website <http://hass.berkeley.edu/~arose>.

<sup>7</sup> More detailed theoretical discussions about this econometric issue are discussed by Maddala (1971) and Hausman (1978).

The second reason for using a random effects model is that the fixed effects model is quite sensitive to errors in variables (Hausman, 1978). Since much of the variation in the data is removed, especially cross-sectional variation, by adding a set of country-pair specific intercept or forming deviations from individual means, the amount of inconsistency would be greater for the fixed effects estimates if errors in variables are present. If there are errors in the variables, the fixed effect estimator is biased and inconsistent, so that the Hausman test is unreliable.<sup>8</sup>

Table 1 summarizes the regression results for each industry sector.<sup>9</sup> Before we interpret the estimated coefficient of our main variable, exchange rate misalignment, it is desirable to check the coefficients of other variables to examine whether our empirical model evidence is consistent with previous studies.

The first pair of variables is exporter's and importer's GDP. According to the recent paper by Feenstra et al. (2001), the parameter values on exporter's and importer's GDP give us useful information to test the so-called 'home market' effect proposed by Krugman (1980). Specifically, they demonstrate that, if exports are differentiated goods, the estimated coefficient of the exporter's GDP should be larger than that of the importer's GDP under the assumption of monopolistic competition. If exports are homogeneous, the estimated coefficients of the exporter's GDP should be smaller than that of the importer's GDP under the assumptions of oligopoly and segmented markets. Furthermore, they show that the estimated coefficient on the exporter's GDP rises as we move from homogeneous to differentiated goods, if Krugman's hypothesis is correct. In our sample, we considered the machinery sector as an industry that produces differentiated products, while the agricultural sector was considered as an industry producing relatively homogeneous products. Our empirical evidence is, in fact, consistent with this interpretation of the estimated coefficients of GDP. In the case of the machinery sector, the estimated coefficient of exporters' GDP is 1.141, which is larger than that of the importers' GDP, 0.96. By contrast, in the case of the agricultural sector, the estimated coefficient of exporter's GDP is -0.555, which is far smaller than that of the importer's GDP, 0.424.

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<sup>8</sup> In our case, the Hausman test suggests a fixed effect model. However, we found that the results of a fixed effect model are unreasonable compared to the results of previous studies (i.e., Bergstrand (1989) and Feenstra et al. (2001)) due to the multicollinearity problem between importer's and exporter's income. These variables are not correlated in a cross-sectional sense but highly correlated in a time-series sense, which produce the unreasonable estimated coefficients. The results of fixed effect models are available from the authors on request.

<sup>9</sup> We use TSCSREG procedure of SAS 8.2 for the regression.

**Table 1. Estimation Results**

	Agriculture	Machinery	Chemicals	Manufacturing
$\ln Y_{it}$	-0.555 <sup>a</sup> (-4.46)	1.141 <sup>a</sup> (15.3)	0.508 <sup>a</sup> (6.97)	0.352 <sup>a</sup> (4.97)
$\ln Y_{jt}$	0.424 <sup>a</sup> (3.42)	0.960 <sup>a</sup> (12.9)	0.703 <sup>a</sup> (9.67)	0.624 <sup>a</sup> (8.79)
$\ln \left( \frac{Y_{it}}{POP_{it}} \right)$	1.223 <sup>a</sup> (7.85)	-0.632 <sup>a</sup> (-7.02)	0.239 <sup>b</sup> (2.45)	-0.347 <sup>a</sup> (-3.69)
$\ln \left( \frac{Y_{jt}}{POP_{jt}} \right)$	-0.809 <sup>a</sup> (-5.19)	-0.102 (-1.13)	-0.275 <sup>a</sup> (-2.82)	0.133 (1.42)
$\ln DIS_{ij}$	0.279 (1.34)	-0.959 <sup>a</sup> (-7.73)	-0.762 <sup>a</sup> (-6.47)	-0.614 <sup>a</sup> (-5.29)
$BORD_{ij}$	1.626 <sup>a</sup> (4.23)	0.123 (0.54)	0.361 <sup>c</sup> (1.71)	0.592 <sup>a</sup> (2.81)
$LANG_{ij}$	0.217 (0.66)	0.232 (1.19)	0.140 (0.78)	0.158 (0.88)
$EU_{ij}$	2.371 <sup>a</sup> (5.57)	0.155 (0.61)	0.401 (1.70)	0.628 <sup>b</sup> (2.68)
$M_{ijt}$	-1.116 <sup>a</sup> (-8.27)	0.070 (0.92)	0.001 (0.01)	0.013 (0.15)
Constant	5.759 <sup>b</sup> (2.53)	14.71 <sup>a</sup> (11.0)	11.09 (8.32)	13.39 <sup>a</sup> (10.3)

Notes: *t*-ratios are in parenthesis; **a**, **b**, and **c** denote significance at the 1, 5, and 10 percent level.

The method of interpretation for the estimated coefficient of exporters' and importers' per capita GDP was introduced by Bergstrand (1989). In his theoretical model, the exporter's per capita GDP represents a proxy variable for the capital-labor ratio of a country. Therefore, a positive (negative) value of the estimated coefficient of the exporter's GDP implies that the industry is capital-intensive (labor-intensive). Conversely, the estimated coefficients of the importer's GDP could be interpreted as usual income elasticity.

In our empirical results, the estimated coefficients for exporters' per capita GDP are positive and statistically significant in the case of the agriculture and chemical sectors, while they are negative in the case of the machinery and manufacturing sectors. The results suggest that products in the agriculture and chemical sectors are capital-intensive, while in the case of the machinery and manufacturing sectors, products are labor-intensive. The estimated coefficients for importers' per capita income are negative and statistically significant for the agriculture and chemical sectors, suggesting that these products are necessities. However, in the case of machinery and manufacturing sectors, the estimated coefficients are positive, although not statistically significant, which implies that products of these industries are luxuries.

In terms of the additional control variables, almost all the time-invariant variables have the expected signs. In the case of the distance variable, all of the estimated coefficients show the expected negative sign and are statistically significant at the 1 percent level, except for the agricultural sector. In the case of the common border variable, the estimated coefficients are all the expected positive signs and are statistically significant at the 1 percent level in the agriculture and manufacturing sectors and at the 10 percent level in the chemical sector. The results suggest that, in the case of the agricultural sector, countries that have a common border trade about 5 times ( $e^{1.626}=5.08$ ) more than countries without a common border. The amount of trade for countries with a common border is 1.4 times ( $e^{0.361}=1.43$ ), and 1.8 times ( $e^{0.592}=1.81$ ) more than that of non-contiguous countries for chemical and manufacturing sectors, respectively.<sup>10</sup>

In the case of the EU dummy variable, the estimated coefficients show the expected positive sign and are statistically significant at the 1 and 5 percent levels for agricultural and manufacturing sectors, respectively. The estimated coefficient for agricultural trade is 2.371. The result implies that, when both countries are members of the EU, trade is 10.7 times ( $e^{2.371}=10.7$ ) greater than if one of the countries is not a member of the EU. The results demonstrate that the trade integration of the EU has been the strongest in the case of the agricultural sector.

Finally, the estimated coefficient of the misalignment measure is statistically significant at the 1 percent level only in the case of agricultural trade. The estimated coefficient is -1.116, which implies that a one-percent over- (under-) valuation of a currency compared to the long-run equilibrium level reduces (increases) agricultural exports by around 1.1 percent. In contrast, we cannot find any statistically significant relationship between variables in other sectors.

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<sup>10</sup> The interpretation of the coefficients of time-invariant variables follows Engel and Rogers (1996), and Rose (2000).



## **Further Investigation**

In the previous section, we used the sample averages of real exchange rates to normalize the misalignment for each country pair. According to the theory of PPP, it is proper to use this normalization. To check the robustness of the regression results, we will use another method of normalization in this section. In this case, the measure of misalignment is calculated by  $M_{ijt}^{1973} = \ln R_{ijt} - \ln R_{ij}^{1973}$ , where  $R_{ij}^{1973}$  is the level of real exchange rate in 1973 for each country pair. Two important points should be emphasized here. First, by equalizing all the real exchange rate measures in 1973, we actually restrict the nominal exchange rates among sample countries in 1973 to the properly aligned nominal exchange rates based on PPP. This restriction also means that real exchange rates in 1973 were long-run equilibrium rates among sample countries. This choice to use 1973 as the base year follows Williamson (1985) and De Grauwe (1988).<sup>11</sup> The underlying rationale of the choice is that, at the starting year of the floating exchange rate system, most developed countries decided their exchange rates using bilateral agreements. Therefore, nominal exchange rates in 1973 could represent properly aligned exchange rates.<sup>12</sup>

The estimation results with the measure of misalignment are presented in Table 2, and the results are similar to those in Table 1. The only exception is a statistically significant positive relationship between exchange rate misalignment and export in the case of the machinery sector. As indicated by Frankel and Romer (1999), this positive relationship might be due to the simultaneity between exchange rate and trade. For instance, if the pattern of export in the machinery sector is important to determine the expectation of foreign exchange market participants, an increasing level of exports in the machinery sector can cause an appreciation of the real exchange rate, resulting in a positive relationship between the variables. However, in the case of the agricultural sector, we still find the estimated coefficient of the misalignment measure is negative and statistically significant at the 1 percent level, indicating the relationship between the variables is robust.

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<sup>11</sup> In his paper, Bergstrand (1985, 1989) chose 1960, 1965, and 1966 as base years.

<sup>12</sup> However, except for this intuitive reason, there is no theoretical reason why we believe real exchange rates among the sample countries are at their long-run equilibrium level in 1973. In fact, no economists know when nominal exchange rates have been perfectly aligned, and this is the reason why measuring misalignment is intrinsically imprecise.

**Table 2. Estimation Results**

	Agriculture	Machinery	Chemicals	Manufacturing
$\ln Y_{it}$	-0.327 <sup>a</sup> (-2.91)	1.146 <sup>a</sup> (16.5)	0.507 <sup>a</sup> (6.94)	0.352 <sup>a</sup> (4.98)
$\ln Y_{jt}$	0.427 <sup>a</sup> (3.80)	0.962 <sup>a</sup> (13.8)	0.703 <sup>a</sup> (9.62)	0.626 <sup>a</sup> (8.84)
$\ln\left(\frac{Y_{it}}{POP_{it}}\right)$	1.092 <sup>a</sup> (7.39)	-0.694 <sup>a</sup> (-8.01)	0.243 <sup>b</sup> (2.50)	-0.361 <sup>a</sup> (-3.85)
$\ln\left(\frac{Y_{jt}}{POP_{jt}}\right)$	-0.915 <sup>a</sup> (-6.19)	-0.047 (-0.54)	-0.278 <sup>a</sup> (-2.85)	0.145 (1.55)
$\ln DIS_{ij}$	0.131 (0.71)	-0.964 <sup>a</sup> (-8.43)	-0.761 <sup>a</sup> (-6.44)	-0.615 <sup>a</sup> (-5.31)
$BORD_{ij}$	1.502 <sup>a</sup> (4.43)	0.118 (0.57)	0.361 <sup>c</sup> (1.71)	0.590 <sup>a</sup> (2.81)
$LANG_{ij}$	0.233 (0.80)	0.233 (1.31)	0.140 (0.78)	0.158 (0.88)
$EU_{ij}$	2.186 <sup>a</sup> (5.80)	0.149 (0.64)	0.402 (1.70)	0.626 <sup>b</sup> (2.68)
$M_{ijt}^{1972}$	-1.244 <sup>a</sup> (-9.35)	0.153 <sup>b</sup> (2.04)	-0.004 (-0.04)	0.033 (0.39)
Constant	7.738 <sup>a</sup> (3.73)	14.77 <sup>a</sup> (11.8)	11.08 (8.30)	13.41 <sup>a</sup> (10.3)

Notes: *t*-ratios are in parenthesis; **a**, **b**, and **c** denote significance at the 1, 5, and 10 percent level.

## CONCLUSION

This paper has focused on whether exchange rate misalignment negatively affects agricultural trade, compared to other sectors. Nominal exchange rate misalignment was obtained from the percentage deviation of real exchange rates from their long-run equilibrium based on the theory of purchasing power parity.

Unlike the usual time-series analysis, we have explored the potential impact on trade associated with *relative* misalignment using panel data. Moreover, we have used more disaggregated data since the effect of misalignment may vary by sector, depending on sectoral characteristics such as the role of sunk costs and durability. In order to explore this issue, we have constructed a bilateral trade matrix involving trade flows between 10 developed countries. Using panel data analysis, a gravity model was estimated for 4 sectors over the period 1974-1999. We have found that overvaluation (undervaluation) of the nominal exchange rate negatively (positively) affects export performance of the agricultural sector in particular. In the large-scale manufacturing sectors considered in this paper, exports are not significantly affected by exchange rate misalignment.

In fact, nominal exchange rates have followed their long-run equilibrium path so that they are cyclically misaligned, at best. Therefore, unlike a short-run effect, the major problem for international agricultural trade caused by exchange rate movement is instability in the long-run. Cyclical booms and depressions of agricultural exports by countries could possibly increase resource-waste within the agricultural sector, resulting in larger dead-weight costs compared to other large-scale industrial sectors.

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